PTO 07-6489

CC=DE DATE=20010315 KIND=A1
PN=19935920

DEVICE AND PROCESS FOR HEATING A STORAGE TANK FOR A REDUCING AGENT OF AN EXHAUST GAS TREATMENT SYSTEM FOR AN INTERNAL COMBUSTION ENGINE
[Vorrichtung und Verfahren zum Beheizen eines Reduktionsmittelvorratsbehaelter einer Abgasnachbehandlungsanlage fuer eine Brennkraftmaschine]

Manfred Weigl

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C August 2007

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19)	DE
DOCUMENT NUMBER	(11)	19935920
DOCUMENT KIND	(12)	A1
PUBLICATION DATE	(43)	20010315
APPLICATION NUMBER	(21)	199 35 920.2
DATE OF FILING	(22)	19990730
ADDITION TO	(61)	
INTERNATIONAL CLASSIFICATION	(51)	F01N 3/10
PRIORITY	(30)	
INVENTORS	(72)	WEIGL, MANFRED
APPLICANT	(71)	SIEMENS AG
DESIGNATED CONTRACTING STATES	(81)	
TITLE	(54)	DEVICE AND PROCESS FOR HEATING A STORAGE TANK FOR A REDUCING AGENT OF AN EXHAUST GAS TREATMENT SYSTEM FOR AN INTERNAL COMBUSTION ENGINE
FOREIGN TITLE	[54A]	VORRICHTUNG UND VERFAHREN ZUM BEHEIZEN EINES REDUKTIONSMITTELVORRATSBEHAELTER EINER ABGASNACHBEHANDLUNGSANLAGE FUER EINE BRENNKRAFTMASCHINE

Description

/1*

The invention relates to a device and a process for heating a storage tank for a reducing agent of an exhaust gas treatment system for an internal combustion engine according to the features of Claims 1 and 11.

Reducing nitrogen oxide emissions of an internal combustion engine which works with an air excess, especially a diesel internal combustion engine, to atmospheric nitrogen (N_2) and water vapor (H_2O) can be done using selective catalytic reduction technology (SCR). Reducing agents are either gaseous ammonia (NH_3), ammonia in an aqueous solution, or urea in an aqueous solution. The urea is used as an ammonia carrier and is injected using a metering system upstream of a hydrolysis catalyst into the exhaust system, reacted there by means of hydrolysis into ammonia, which then in turn reduces the nitrogen oxides in the actual SCR or DENOX catalyst.

This metering system as an important component has a reducing agent tank, a pump, a pressure regulator, a pressure sensor and a metering valve. The pump conveys the reducing agent stored in the reducing agent tank, by means of which the reducing agent is injected into the exhaust gas flow upstream of the hydrolysis catalyst. The metering valve is triggered via signals of a control means such that depending on the operating parameters the internal combustion engine is supplied with a certain amount of reducing agent which is required at the time (DE 197 43 337 C1).

One advantage of the ammonia-releasing substances such as for example urea which are present in aqueous solutions is that storage,

---

* Numbers in the margin indicate pagination in the foreign text.

handling, conveying capacity and metering capacity can be relatively easily accomplished in technical terms. One disadvantage of these aqueous solutions is that depending on the concentration of the dissolved substances, there is the danger of freezing at certain temperatures.

A 32% urea solution, as is typically used in SCR system as a reducing agent, has a freezing point of -11°C. Therefore devices for heating of the metering system must be provided to ensure serviceability of all system components after system start at ambient temperatures less than -11°C within an acceptable time and to prevent the system components from freezing during operation.

DE 44 32 577 A1 discloses a means for preventing frost damage to parts of an exhaust gas cleaning system which works according to the principle of selective catalytic reduction during down times and for enabling operation of these systems below the freezing point of the reducing agent solution used. For this purpose the means has a thermally insulated storage tank for the reducing agent solution and a supply line connected to it which ends in the exit opening for the liquid, in the supply line a backflush valve being provided which can be supplied with a pressurized gas. The storage tank and the supply line can be heated by means of electrical heating which supplies heat to a heat exchanger.

In order to ensure operating readiness of the metering system at such low temperatures, the reducing agent storage tanks, lines, valves, pumps and pressure sensors in the reducing agent system must be heated. For components which contain only small volumes of reducing agents, electrical heaters are well suited. But for the reducing agent storage

tank the power consumption of an electrical heating system is unacceptably high. This applies especially in systems which have a relatively high consumption of reducing agent over long periods. Thus, at a reducing agent consumption of 51 per hour a heating output of roughly 500 W is necessary to deliver the melting heat for this amount of reducing agent. In commercial vehicle applications this consumption of reducing agent must be expected under certain driving conditions. To additionally make available a reserve of reducing agent and to compensate for heat losses through the wall of the tank, the demand for heat output for the reducing agent storage tank alone can exceed 1 kW.

The object of the invention is to devise a device and a process with which freezing of the reducing agent stored in the reducing agent storage tank can be reliable avoided.

The object is achieved for the device by the features of Claim 1 and for the process by the features of Claim 11.

The idea underlying the invention is based on making available heat output for the reducing agent stored in the reducing agent storage tank by the exhaust heat of the internal combustion engine by routing the coolant of the internal combustion engine, generally a mixture of water containing as little lime as possible, antifreeze and additives for corrosion protection through heating tubes in the reducing agent storage tank.

Since the reducing agents used in these SCR systems should not be heated above certain temperatures to avoid premature ageing, and the normal temperature of the coolant for internal combustion engines which are hot from operation is above 80°C (opening temperature of the coolant thermostat) and under certain circumstances reaches 110°C,

during the thawing phase under certain circumstances, depending on the type of reducing agent used, local overheating of the reducing agent can take place.

According to advantageous developments of the invention therefore measures are provided which enable limitation of the coolant temperature and thus limitation of the heat output which is supplied to the reducing agent.

By using a heat exchanger between the feed and return for the coolant, the temperature of the coolant can be effectively reduced. In addition, in one preferred version, in the feed line there can be an electrically triggerable solenoid valve which when a given temperature of the reducing agent is reached blocks further coolant flow. In this way it is ensured that the temperature rise in the reducing agent storage tank is limited even when high outside temperatures occur.

If for the feed and return of the coolant, lines are used which are parallel and with good thermal contact to one another over a given length, a heat exchanger of simple structure results which cools the coolant of the internal combustion engine in the feed to the extent that local overheating of reducing agents in the reducing agent storage tank is precluded. With this device even for internal combustion engines which are hot from operation the thawing phase can be continued without limitation or heating can be continued in order to prevent freezing of the reducing agent storage tank during operation at low ambient temperatures.

The heat exchanger can be produced very economically as part of the hose connections. To achieve good thermal contact between the feed line and return line the corresponding line sections can consist /2

either of metallic material and are connected by means of suitable connections such as hose clips or the like with hoses to the feed line and return line and directly to the respective outside walls, for example soldered, welded or cemented. If metallic line sections for the heat exchanger are omitted, it is advantageous to move the hoses into close contact with one another with interposition of a material with good thermal conductivity, such as for example aluminum. For this purpose an aluminum section can be used which according to the diameters of the hoses has recesses into which the hoses are inserted and which at the same time is used as a guide and holding element for the hoses.

Devices of simple structure which are thus economical for heating of the reducing agent storage tank result when instead of a solenoid valve automatic thermostat valves are used either in the feed line and/or in the return line, which open and close at certain given values for temperature.

Other advantageous configurations of the invention are explained below with reference to the drawings.

Figure 1 shows a block diagram of an internal combustion engine with the pertinent exhaust gas treatment system and devices for heating the reducing agent,

Figure 2 shows a first embodiment of a device for heating the reducing agent,

Figure 3 shows a second embodiment of a device for heating the reducing agent,

Figure 4 shows a third embodiment of a device for heating the reducing agent, and

Figure 5 shows a fourth embodiment of a device for heating a reducing agent.

Figure 1 in the form of a block diagram shows very simplified an internal combustion engine operated with an air excess with an exhaust gas treatment system assigned to it and a device for heating the reducing agent for such an exhaust gas treatment system. Here only those parts are shown which are necessary for the understanding of the invention. In particular the fuel circuit is not shown. In this embodiment the internal combustion engine is a diesel internal combustion engine and aqueous urea solution is used as the reducing agent.

The internal combustion engine 1 is supplied with the air necessary for combustion via an intake line 2. An injection system which can be made for example as a high pressure storage injection system (common rail) with injection valves which inject the fuel KST directly into the cylinders of the internal combustion engine 1 is labeled with reference number 3. The exhaust gas of the internal combustion engine 1 flows via an exhaust gas line 4 to an exhaust gas treatment system 5 and from the latter via a muffler which is not shown into the open.

To control the internal combustion engine 1 a known engine control device 6 is connected to the internal combustion engine 1 via a data and control line 7 which is shown only schematically here. This data and control line 7 carries signals from sensors (for example, temperature sensors for intake air, charging air, coolant, a load sensor, speed sensor) and signals for actuators (for example injection valves, final control elements) between the internal combustion engine

1 and the engine control device 6.

The exhaust gas treatment system 5 has a reducing catalytic converter 8 which contains several series connected catalytic units which are not detailed. Downstream and/or upstream of the reducing catalytic converter 8, there can additionally be one oxidation catalytic converter each (not shown). Furthermore there is a metering control device 9 which is assigned to the reducing agent storage tank 10 with an electrically triggerable reducing agent pump 11 for conveying the reducing agent.

The reducing agent in this embodiment is an aqueous urea solution which is stored in the reducing agent storage tank 10. The latter has sensors 13, 14 which detect the temperature of the aqueous urea solution or the fill level in the reducing agent storage tank 10, and a heating means 12 which is connected to the cooling circuit of the internal combustion engine and is detailed using the following Figures 2-5.

Moreover the signals of a temperature sensor located upstream of the reducing catalytic converter 8 and an exhaust gas sensor, for example a NOx sensor (not shown), located downstream of the reducing catalytic converter 8, are transferred to the metering control device 9.

The metering control device 9 controls an electromagnetic metering valve 15 to which if necessary via a supply line 16 a urea solution is supplied using the reducing agent pump 11 from the reducing agent storage tank 10. A pressure sensor 18 is inserted into the supply line 16 and detects the pressure in the metering system and delivers a corresponding signal to the metering control device 9. The injection of

the urea solution by means of the metering valve 15 takes place into the exhaust gas line 4 upstream of the reducing catalytic converter 8.

In operation of the internal combustion engine 1 the exhaust gas flows through the exhaust line 4 in the illustrated direction of the arrow.

The metering control device 9 is connected to the engine control device 6 for mutual data transfer via an electrical bus system 17. Via the bus system 17 the operating parameters relevant for computing the amount of urea solution to be metered, such as for example engine rpm, air mass, fuel mass, control path of an injection pump, exhaust gas mass flow, operating temperature, charging air temperature, start of injection, etc., are transferred to the metering control device 9.

It is also possible to integrate the functions of the metering control device 9 for the reducing agent metering system into the engine control device 6 of the internal combustion engine.

Proceeding from these parameters and the measured values for the exhaust gas temperature and the NO_x content, the metering control device 9 computes the amount of urea solution to be injected and delivers via an electrical connecting line 18 a corresponding electrical signal to the metering valve 15. By injection into the exhaust gas line 4 the urea is hydrolyzed and thoroughly mixed. In the catalytic units, catalytic reduction of NO_x in the exhaust gas to N_2 and H_2O takes place.

The metering valve 15 for delivering the urea solution into the exhaust gas line 4 corresponds largely to a conventional low pressure gasoline injection valve which is detachably fastened for example in a valve holding device which is permanently connected to the wall of the

exhaust gas line 4.

To cool the internal combustion engine 1 there is a cooling means 30 for the cooling circuit which has an equalization tank 25, a radiator 26, a radiator thermostat 27, a coolant pump 28 for forced recirculation cooling, a cooling jacket which is not detailed around the cylinders of the internal combustion engine, and the connecting lines necessary for this purpose and a vehicle heating system 29 /3 which heats the vehicle interior. This arrangement for cooling the internal combustion engine is common so that its manner of operation will not be detailed here. The heating device 12 for the reducing agent storage tank 10 is connected to the coolant circuit of the internal combustion engine 1 by means of two lines 19, 21 which are detailed below.

Figure 2 shows a first embodiment of such a heating device for a reducing agent storage tank 10. Coolant flows via a feed line 19 which is connected to the coolant circuit of the internal combustion engine 1 to the reducing agent storage tank 10 in which there is a heating element 20 in the form of a heating coil for heating the reducing agent. The coolant releases heat to the reducing agent and flows back via the return line 21 to the cooling circuit of the internal combustion engine 1.

For feed and return of the coolant, lines are used which are laid over a given length parallel and with good thermal contact to one another. This yields a heat exchanger 22. Via this heat exchanger the coolant flows from the internal combustion engine 1 to the heating element 20 in the reducing agent storage tank 10 and in the opposite direction from the reducing agent storage tank 10 back to the internal

combustion engine 1. An electrical solenoid valve 23 which can be triggered via signals of the metering control device 9 in inserted into the feed line 19 upstream of the heat exchanger 22. This solenoid valve 23 is provided since in spite of the heat exchanger 22 the temperature rise in the reducing agent storage tank 10 is not automatically limited and at high outside temperatures the tank would be additionally heated. Therefore, depending on the signal of the temperature sensor 13 (Figure 1) which detects the temperature of the reducing agent in the reducing agent storage tank, the feed line 19 is either cleared or blocked. The temperature value at which heating of the reducing agent is no longer necessary and thus the heating circuit can be interrupted, can be chosen depending on the reducing agent used.

Figure 3 shows a simpler and more economical version than the above described heating device, for the same components the same reference numbers being used. In this embodiment, instead of the solenoid valve 23 there is a thermostat valve 24R in the return line 21 between the heating element 20 and heat exchanger 22. This thermostat valve 24R is designed such that it is open when opened below a given value for the reducing agent temperature and when this temperature value is reached, it closes. If for example 20°C is chosen as the closing temperature, it is ensured that starting from a reducing agent temperature of 20°C the reducing agent storage tank is not heated.

When using aqueous 32.5 percent urea solution as the reducing agent, the melting point is -11°C, i.e. the return itself has a high enough temperature relative to the frozen reducing agent to heat efficiently. In this system the efficiency of the heat exchanger and the maximum coolant flow rate must be matched to one another such that

the feed temperature does not exceed a value of 60°C for a long interval. Under certain conditions (minimized heat exchanger but very efficient heating element) it is advantageous to limit not the return temperature with the thermostat valve, but the feed temperature on the heating element 20.

Figure 4 shows such an arrangement. Here there is a thermostat valve 24V in the feed line 19 downstream of the heat exchanger 22 and the heating element 20. The advantage of this arrangement consists in that the maximum temperature of the heating element 20 is limited directly by the thermostat valve 24. The maximum heating temperature can thus never be higher than the closing temperature of the thermostat valve 24V.

It is also possible to combine the advantages of the two aforementioned embodiments as shown in Figures 3 and 4. To do this, as is shown in Figure 5, a thermostat valve 24V is installed in the feed line 19 downstream of the heat exchanger 22 and a thermostat valve 24R is installed in the return line 21 upstream of the heat exchanger 22. The thermostat valve 24V in the feed line 19 can be set for example to 60°C, the thermostat valve 24R in the return line 21 to 20°C. With this arrangement it is possible if necessary to heat with a feed temperature of 60°C. As soon as the reducing agent temperature exceeds a value of 20°C, the thermostat valve 24R closes and external heat output is no longer supplied via the coolant to the internal combustion engine.

Claims

1. Device for heating a storage tank for a reducing agent of an exhaust gas treatment system which operates according to the principle of selective catalytic reduction of nitrogen oxides for an internal combustion engine which has a cooling means which is operated with liquid coolant, characterized in that in the reducing agent storage tank (10) there is a heating element (20) which is connected via a feed line (19) and a return line (21) to the cooling means (30) of the internal combustion engine (1).

2. Device as claimed in Claim 1, wherein the feed line (19) and the return line (21) are arranged relative to one another at least in sections such that they form a heat exchanger (22).

3. Device as claimed in Claim 2, wherein the feed line (19) and the return line (21) are located parallel in good thermal contact to one another and the flow direction of the coolant in the feed line (19) is opposite the flow direction of the coolant in the return line (21).

4. Device as claimed in one of Claims 1-3, wherein in the feed line (19) there is an electrically triggerable valve (23) which blocks the flow of the coolant to the heating element (20) in the reducing agent storage tank (10) at a given reducing agent temperature.

5. Device as claimed in one of Claims 1-3, wherein in the return line (21) there is a thermostat valve (24R) which enables flow of the coolant below a given value for the reducing agent temperature, and when this value is reached, blocks the flow of coolant.

6. Device as claimed in Claim 2 and 5, wherein the thermostat valve (24R) in the return line (21) is located in the line branch between the heating element (20) and the heat exchanger (22).

7. Device as claimed in one of Claims 1-3, wherein in the feed line (19) there is a thermostat valve (24V) which limits the feed /4 temperature.

8. Device as claimed in Claim 2 and 7, wherein the thermostat valve (24V) is located in the feed line (19) branch between the heat exchanger (22) and the heating element (20).

9. Device as claimed in one of Claims 1-3, wherein in the feed line (19) there is a thermostat valve (24V) and in the return line (21) there is a thermostat valve (24R).

10. Device as claimed in Claim 2 and 9, wherein the thermostat valve (24V) in the feed line (19) is located in the line branch between the heat exchanger (22) and the heating element (20) and the thermostat valve (24R) in the return line (21) is located in the line branch between the heating element (20) and the heat exchanger (22).

11. Process for heating a storage tank for a reducing agent of an exhaust gas treatment system which operates according to the principle of selective catalytic reduction of nitrogen oxides for an internal combustion engine which is cooled using a cooling means with liquid coolant, wherein the reducing agent stored in the reducing agent storage tank (10) is heated by the exhaust heat of the internal combustion engine (1) which has been transported via the coolant.

12. Process as claimed in Claim 11, wherein the coolant is routed via a feed line (19) to a heating element (20) which is assigned to the reducing agent storage tank (10) and via a return line (21) back to the cooling means (30) of the internal combustion engine (1).

13. Process as claimed in Claim 11, wherein in the feed line (19) and/or the return line (21) there are means (23, 22, 24V, 24R) which

limit the temperature of the coolant to given values.

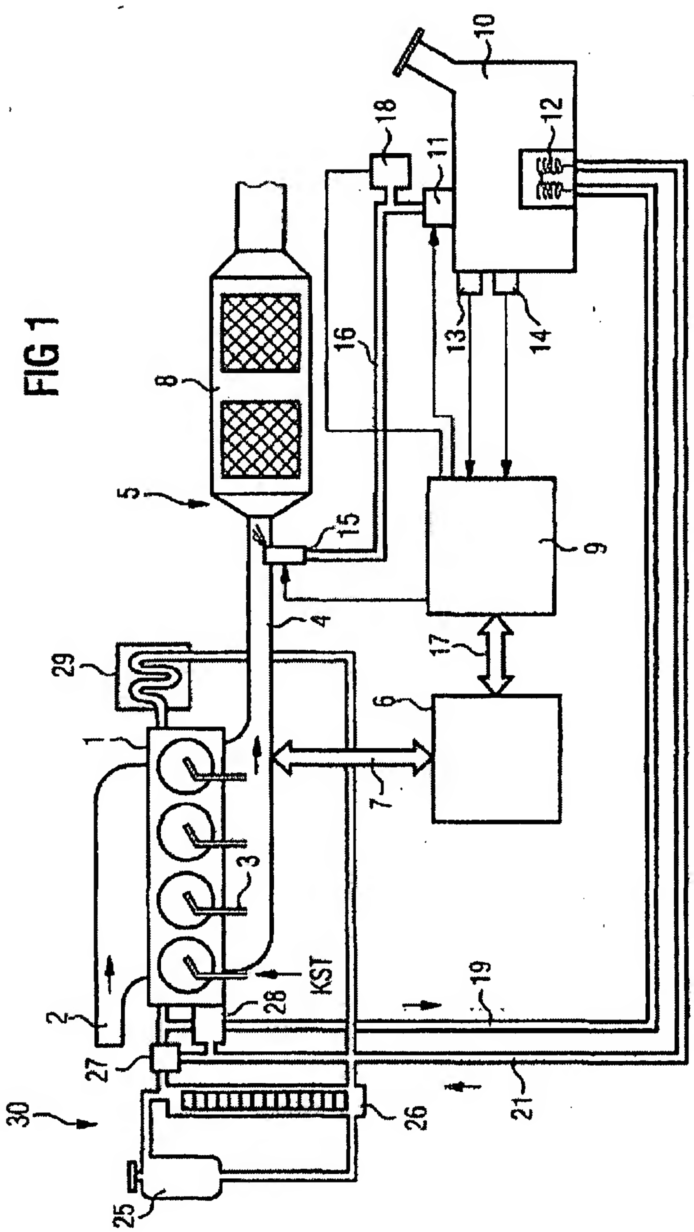
14. Process as claimed in Claim 13, wherein the means comprise a heat exchanger (22) formed from a feed line (19) and return line (21).

15. Process as claimed in Claim 13, wherein the means comprise thermostat valves (24V, 24R).

---

3 pages of drawings attached

FIG 1



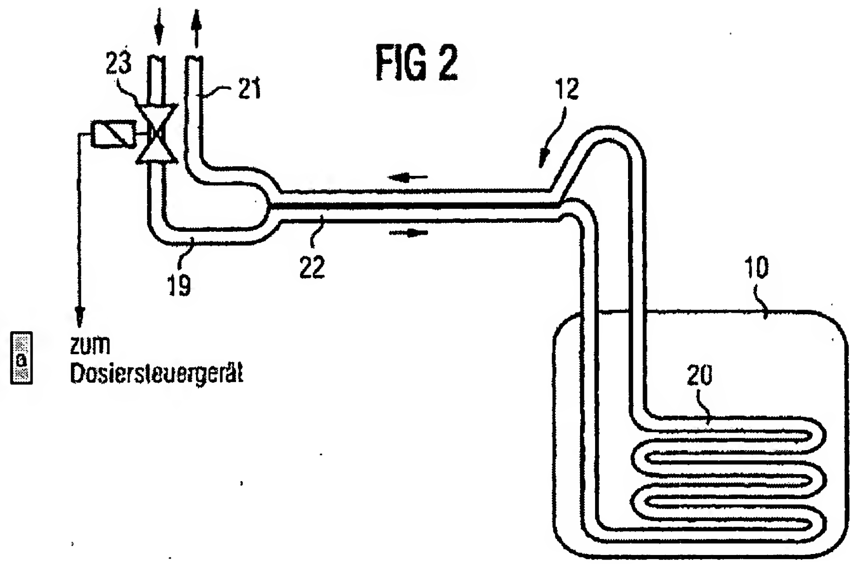


FIG 2

Key: a) to metering control device

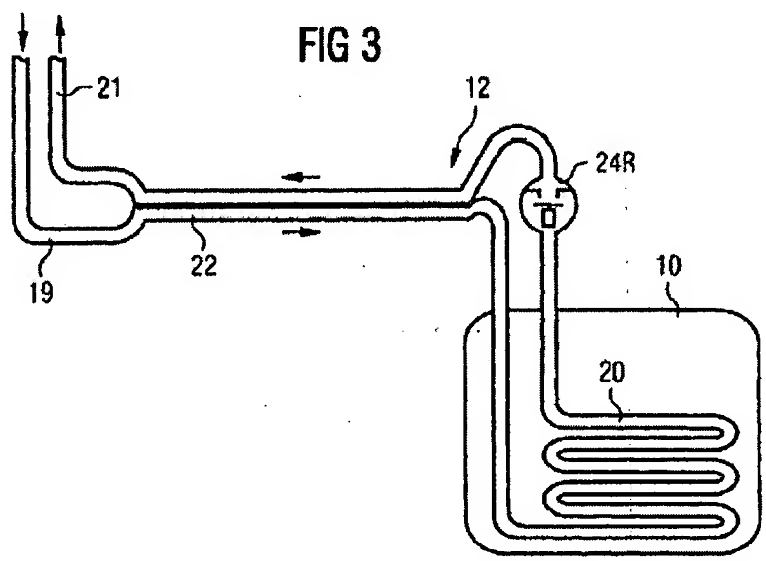


FIG 3

FIG 4

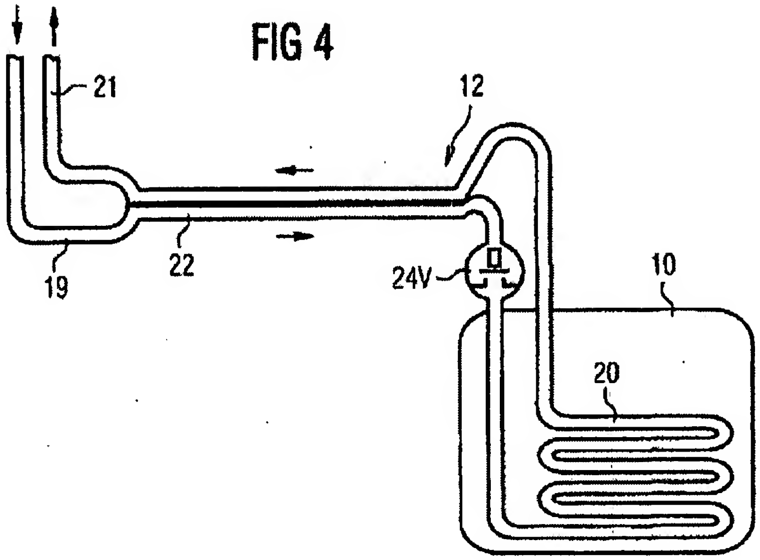


FIG 5